# 37

# Asymmetric Information

# Information in Competitive Markets

- In purely competitive markets all agents are fully informed about traded commodities and other aspects of the market.
- What about markets for medical services, or insurance, or used cars?

# Asymmetric Information in Markets

- A doctor knows more about medical services than does the buyer.
- An insurance buyer knows more about his riskiness than does the seller.
- A used car's owner knows more about it than does a potential buyer.

# Asymmetric Information in Markets

- Markets with one side or the other imperfectly informed are markets with imperfect information.
- Imperfectly informed markets with one side better informed than the other are markets with asymmetric information.

# Asymmetric Information in Markets

- In what ways can asymmetric information affect the functioning of a market?
- Four applications will be considered:
  - adverse selection
  - signaling
  - moral hazard
  - incentives contracting.

# Adverse Selection

- Consider a used car market.
- Two types of cars; “lemons” and “peaches”.
- Each lemon seller will accept \$1,000; a buyer will pay at most \$1,200.
- Each peach seller will accept \$2,000; a buyer will pay at most \$2,400.

# Adverse Selection

- If every buyer can tell a peach from a lemon, then lemons sell for between $1,000 and $1,200, and peaches sell for between $2,000 and $2,400.
- Gains-to-trade are generated when buyers are well informed.

# Adverse Selection

- Suppose no buyer can tell a peach from a lemon before buying.
- What is the most a buyer will pay for any car?

# Adverse Selection

- Let *q* be the fraction of peaches.
- 1 - *q* is the fraction of lemons.
- Expected value to a buyer of any car is at most

$$\mathbf{EV = \$1200(1 - q) + \$2400q.}$$

# Adverse Selection

- Suppose EV > $2000.
- Every seller can negotiate a price between $2000 and $EV (no matter if the car is a lemon or a peach).
- All sellers gain from being in the market.

# Adverse Selection

- Suppose EV < $2000.
- A peach seller cannot negotiate a price above $2000 and will exit the market.
- So all buyers know that remaining sellers own lemons only.
- Buyers will pay at most $1200 and only lemons are sold.

# Adverse Selection

- Hence “too many” lemons “crowd out” the peaches from the market.
- Gains-to-trade are reduced since no peaches are traded.
- The presence of the lemons inflicts an external cost on buyers and peach owners.

# Adverse Selection

- How many lemons can be in the market without crowding out the peaches?
- Buyers will pay $2000 for a car only if

$$EV = \$1200(1-q) + \$2400q \geq \$2000$$

# Adverse Selection

- How many lemons can be in the market without crowding out the peaches?
- Buyers will pay \$2000 for a car only if

$$EV = \$1200(1-q) + \$2400q \geq \$2000$$

$$\Rightarrow q \geq \frac{2}{3}.$$

- So if over one-third of all cars are lemons, then only lemons are traded.

# Adverse Selection

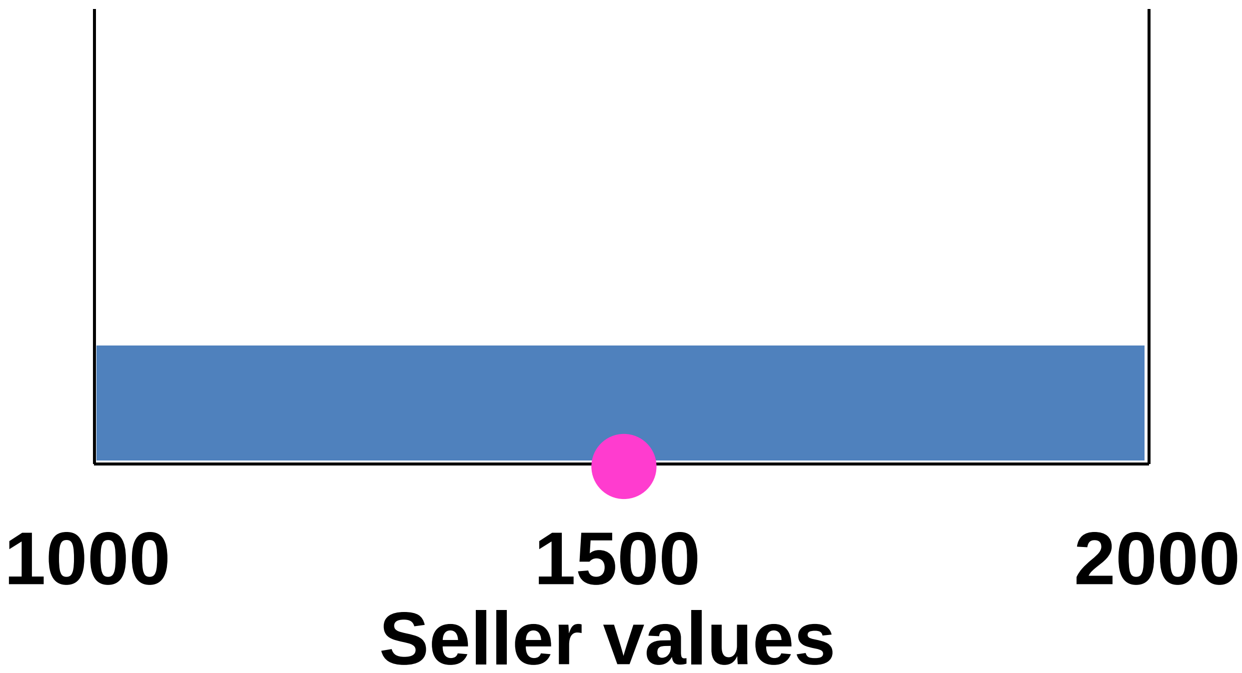
- A market equilibrium in which both types of cars are traded and cannot be distinguished by the buyers is a pooling equilibrium.
- A market equilibrium in which only one of the two types of cars is traded, or both are traded but can be distinguished by the buyers, is a separating equilibrium.

# Adverse Selection

- What if there is more than two types of cars?
- Suppose that
  - car quality is Uniformly distributed between \$1000 and \$2000
  - any car that a seller values at \$x is valued by a buyer at \$(x+300).
- Which cars will be traded?

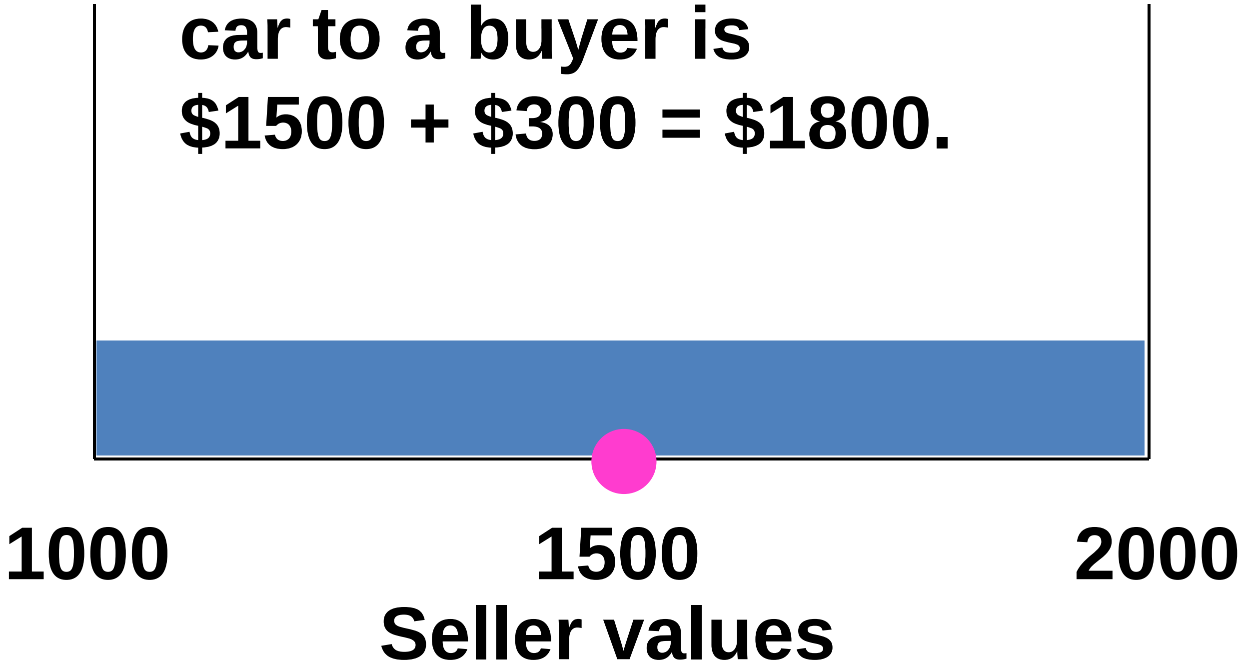
# Adverse Selection

# Adverse Selection



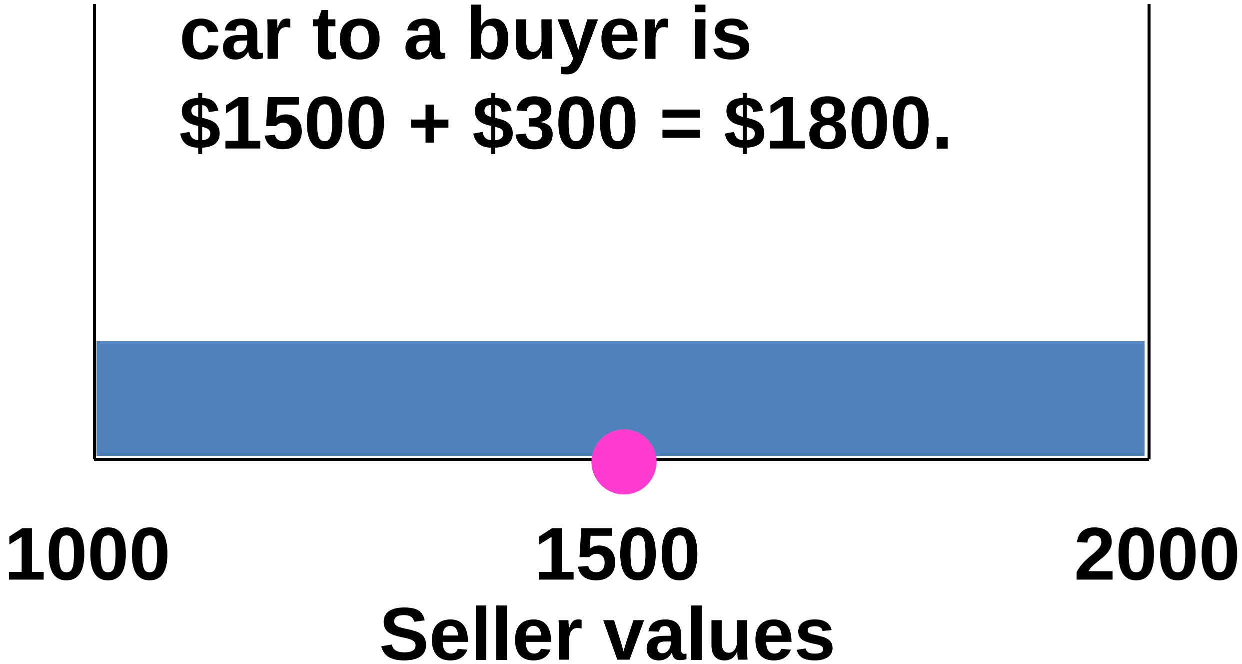
# Adverse Selection

**The expected value of any car to a buyer is $1500 + $300 = $1800.**



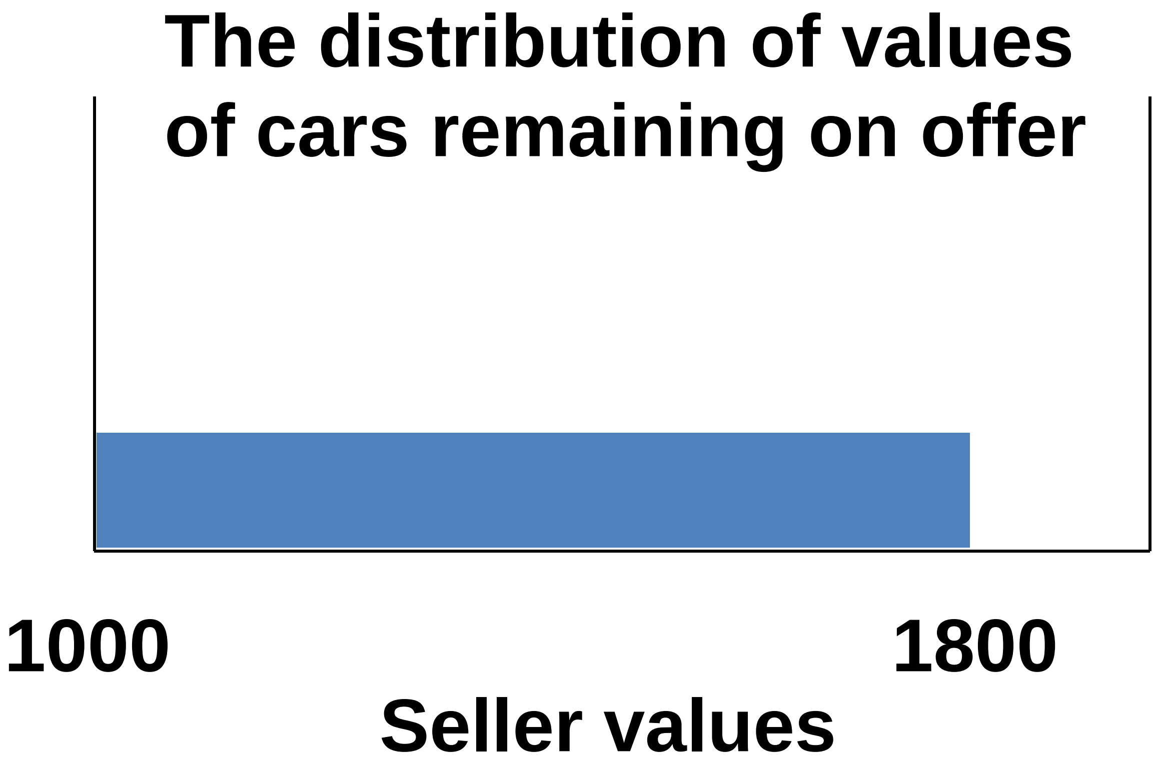
# Adverse Selection

**The expected value of any car to a buyer is $1500 + $300 = $1800.**

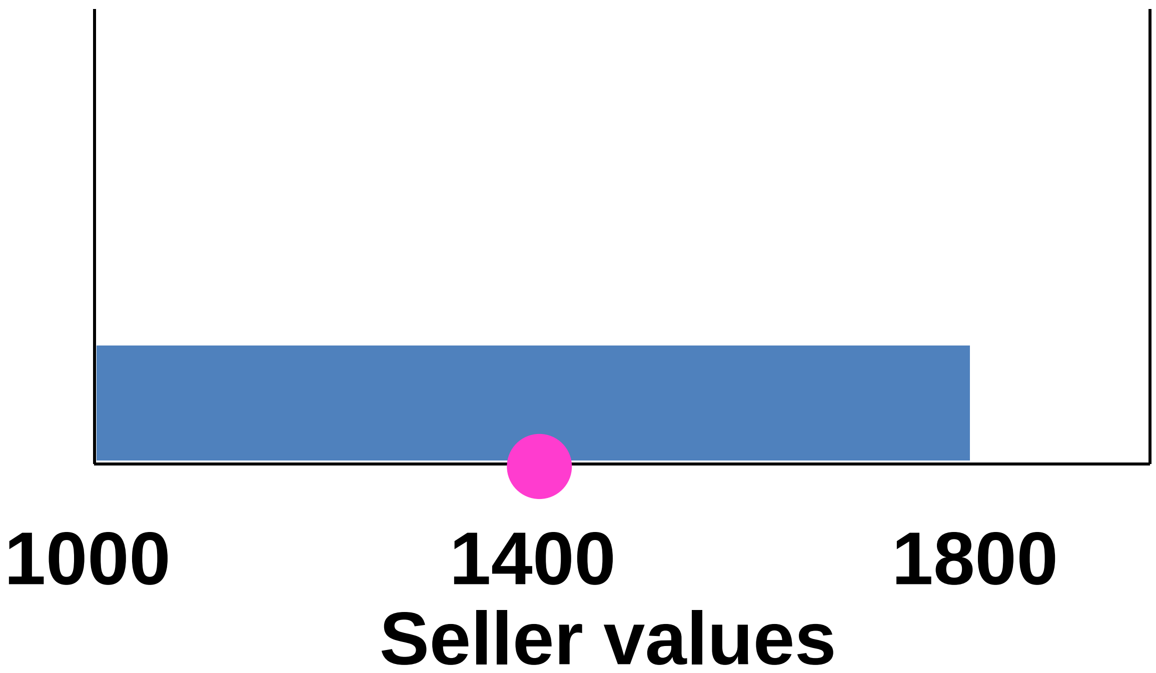



**So sellers who value their cars at more than $1800 exit the market.**

# Adverse Selection

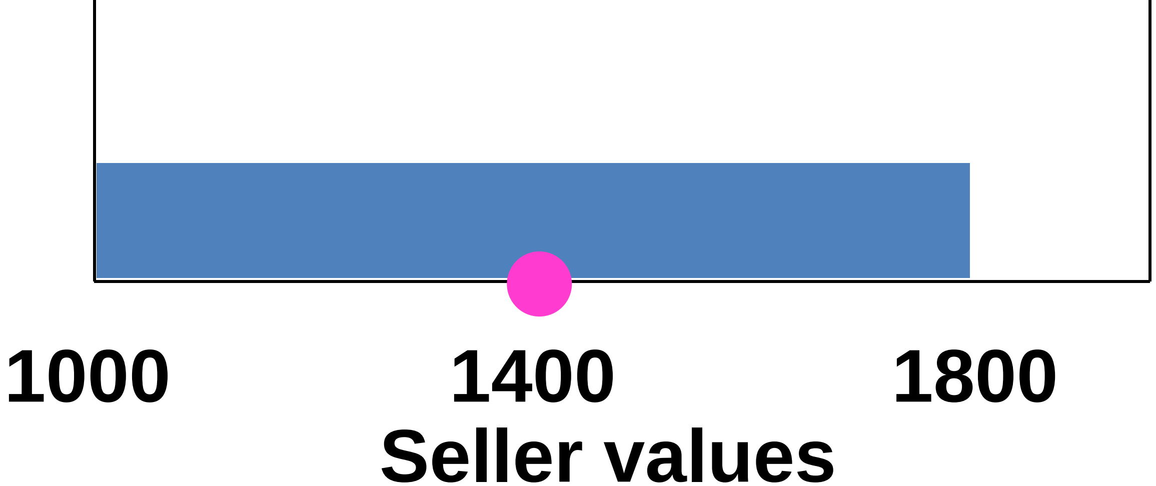


# Adverse Selection



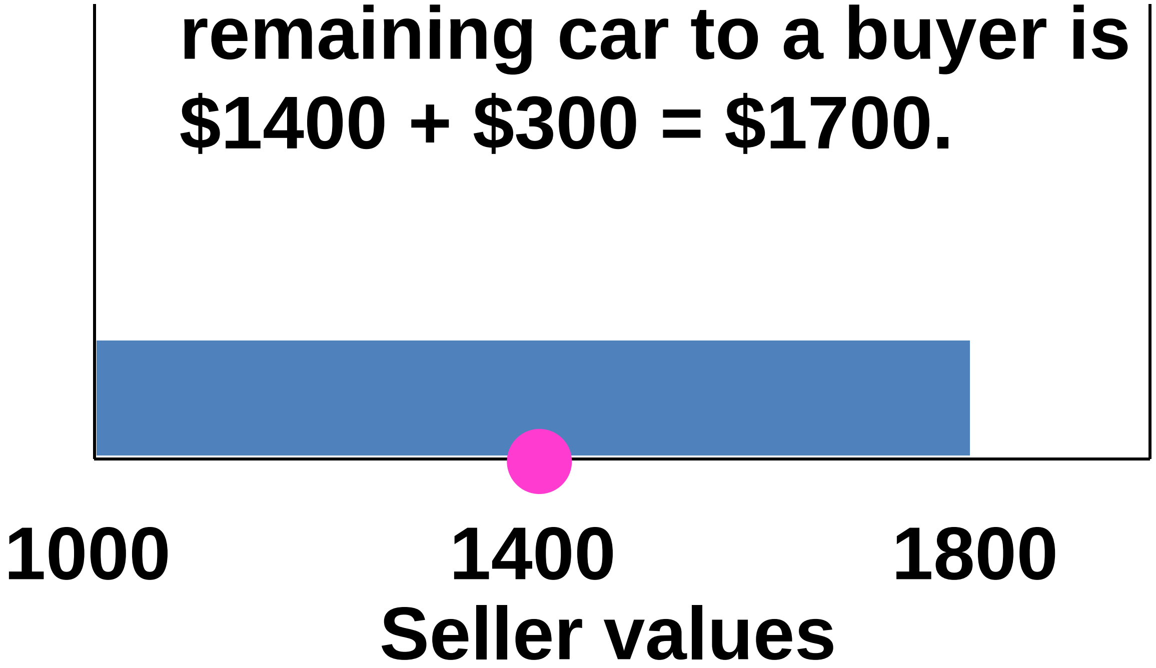
# Adverse Selection

**The expected value of any remaining car to a buyer is $1400 + $300 = $1700.**



# Adverse Selection

**The expected value of any remaining car to a buyer is $1400 + $300 = $1700.**




**So now sellers who value their cars between $1700 and $1800 exit the market.**

# Adverse Selection

- Where does this unraveling of the market end?
- Let $v_H$ be the highest seller value of any car remaining in the market.
- The expected seller value of a car is

$$\frac{1}{2} \times 1000 + \frac{1}{2} \times v_H.$$

# Adverse Selection

- So a buyer will pay at most

$$\frac{1}{2} \times 1000 + \frac{1}{2} \times v_H + 300.$$

# Adverse Selection

- So a buyer will pay at most

$$\frac{1}{2} \times 1000 + \frac{1}{2} \times v_H + 300.$$

- This must be the price which the seller of the highest value car remaining in the market will just accept; i.e.

$$\frac{1}{2} \times 1000 + \frac{1}{2} \times v_H + 300 = v_H.$$

# Adverse Selection

$$\frac{1}{2} \times 1000 + \frac{1}{2} \times v_H + 300 = v_H$$

$$\Rightarrow \; v_H = \$1600.$$

**Adverse selection drives out all cars valued by sellers at more than $1600.**

# Adverse Selection with Quality Choice

- Now each seller can choose the quality, or value, of her product.
- Two umbrellas; high-quality and low-quality.
- Which will be manufactured and sold?

# Adverse Selection with Quality Choice

- Buyers value a high-quality umbrella at \$14 and a low-quality umbrella at \$8.
- Before buying, no buyer can tell quality.
- Marginal production cost of a high-quality umbrella is \$11.
- Marginal production cost of a low-quality umbrella is \$10.

# Adverse Selection with Quality Choice

- Suppose every seller makes only high-quality umbrellas.
- Every buyer pays \$14 and sellers' profit per umbrella is \$14 - \$11 = \$3.
- But then a seller can make low-quality umbrellas for which buyers still pay \$14, so increasing profit to
  \$14 - \$10 = \$4.

# Adverse Selection with Quality Choice

- There is no market equilibrium in which only high-quality umbrellas are traded.
- Is there a market equilibrium in which only low-quality umbrellas are traded?

# Adverse Selection with Quality Choice

- All sellers make only low-quality umbrellas.
- Buyers pay at most $8 for an umbrella, while marginal production cost is $10.
- There is no market equilibrium in which only low-quality umbrellas are traded.

# Adverse Selection with Quality Choice

- Now we know there is no market equilibrium in which only one type of umbrella is manufactured.
- Is there an equilibrium in which both types of umbrella are manufactured?

# Adverse Selection with Quality Choice

- A fraction $q$ of sellers make high-quality umbrellas; $0 < q < 1$.
- Buyers' expected value of an umbrella is
  $$EV = 14q + 8(1 - q) = 8 + 6q.$$
- High-quality manufacturers must recover the manufacturing cost,
  $$EV = 8 + 6q \geq 11 \Rightarrow q \geq 1/2.$$

# Adverse Selection with Quality Choice

- So at least half of the sellers must make high-quality umbrellas for there to be a pooling market equilibrium.
- But then a high-quality seller can switch to making low-quality and increase profit by $1 on each umbrella sold.

# Adverse Selection with Quality Choice

- Since all sellers reason this way, the fraction of high-quality sellers will shrink towards zero -- but then buyers will pay only $8.
- So there is no equilibrium in which both umbrella types are traded.

# Adverse Selection with Quality Choice

- The market has no equilibrium
  - with just one umbrella type traded
  - with both umbrella types traded

# Adverse Selection with Quality Choice

- The market has no equilibrium
  - with just one umbrella type traded
  - with both umbrella types traded
- so the market has no equilibrium at all.

# Adverse Selection with Quality Choice

- The market has no equilibrium
  - with just one umbrella type traded
  - with both umbrella types traded
- so the market has no equilibrium at all.
- Adverse selection has destroyed the entire market!

# Signaling

- Adverse selection is an outcome of an informational deficiency.
- What if information can be improved by high-quality sellers signaling credibly that they are high-quality?
- E.g. warranties, professional credentials, references from previous clients etc.

# Signaling

- A labor market has two types of workers; high-ability and low-ability.
- A high-ability worker’s marginal product is $a_H$.
- A low-ability worker’s marginal product is $a_L$.
- $a_L < a_H$.

# Signaling

- A fraction $h$ of all workers are high-ability.
- 1 - $h$ is the fraction of low-ability workers.

# Signaling

- Each worker is paid his expected marginal product.
- If firms knew each worker's type they would
  - pay each high-ability worker $w_H = a_H$
  - pay each low-ability worker $w_L = a_L$.

# Signaling

- If firms cannot tell workers’ types then every worker is paid the (pooling) wage rate; i.e. the expected marginal product

$$w_P = (1 - h)a_L + ha_H.$$

# Signaling

- $w_P = (1 - h)a_L + ha_H < a_H$, the wage rate paid when the firm knows a worker really is high-ability.
- So high-ability workers have an incentive to find a credible signal.

# Signaling

- Workers can acquire "education".
- Education costs a high-ability worker $c_H$ per unit
- and costs a low-ability worker $c_L$ per unit.
- $c_L > c_H$.

# Signaling

- Suppose that education has no effect on workers' productivities; i.e., the cost of education is a deadweight loss.

# Signaling

- High-ability workers will acquire $e_H$ education units if
  (i) $w_H - w_L = a_H - a_L > c_H e_H$, and
  (ii) $w_H - w_L = a_H - a_L < c_L e_H$.

# Signaling

- High-ability workers will acquire $e_H$ education units if
  (i) $w_H - w_L = a_H - a_L > c_H e_H$, and
  (ii) $w_H - w_L = a_H - a_L < c_L e_H$.
- (i) says acquiring $e_H$ units of education benefits high-ability workers.

# Signaling

- High-ability workers will acquire $e_H$ education units if
  (i) $w_H - w_L = a_H - a_L > c_H e_H$, and
  (ii) $w_H - w_L = a_H - a_L < c_L e_H$.
- (i) says acquiring $e_H$ units of education benefits high-ability workers.
- (ii) says acquiring $e_H$ education units hurts low-ability workers.

# Signaling

$a_H - a_L > c_H e_H$ **and** $a_H - a_L < c_L e_H$

**together require**

$$\frac{a_H - a_L}{c_L} < e_H < \frac{a_H - a_L}{c_H}.$$

**Acquiring such an education level credibly signals high-ability, allowing high-ability workers to separate themselves from low-ability workers.**

# Signaling

- Q: Given that high-ability workers acquire $e_H$ units of education, how much education should low-ability workers acquire?

# Signaling

- Q: Given that high-ability workers acquire $e_H$ units of education, how much education should low-ability workers acquire?
- A: Zero. Low-ability workers will be paid $w_L = a_L$ so long as they do not have $e_H$ units of education and they are still worse off if they do.

# Signaling

- Signaling can improve information in the market.
- But, total output did not change and education was costly so signaling worsened the market’s efficiency.
- So improved information need not improve gains-to-trade.

# Moral Hazard

- If you have full car insurance are you more likely to leave your car unlocked?
- Moral hazard is a reaction to incentives to increase the risk of a loss
- and is a consequence of asymmetric information.

# Moral Hazard

- If an insurer knows the exact risk from insuring an individual, then a contract specific to that person can be written.
- If all people look alike to the insurer, then one contract will be offered to all insurees; high-risk  and low-risk types are then pooled, causing low-risks to subsidize high-risks.

# Moral Hazard

- Examples of efforts to avoid moral hazard by using signals are:
  - higher life and medical insurance premiums for smokers or heavy drinkers of alcohol
  - lower car insurance premiums for contracts with higher deductibles or for drivers with histories of safe driving.

# Incentives Contracting

- A worker is hired by a principal to do a task.
- Only the worker knows the effort she exerts (asymmetric information).
- The effort exerted affects the principal's payoff.

# Incentives Contracting

- The principal's problem: design an incentives contract that induces the worker to exert the amount of effort that maximizes the principal's payoff.

# Incentives Contracting

- *e* is the agent's effort.
- Principal's reward is $y = f(e).$
- An incentive contract is a function *s*(*y*) specifying the worker's payment when the principal's reward is *y*. The principal's profit is thus

$$\Pi_p = y - s(y) = f(e) - s(f(e)).$$

# Incentives Contracting

- Let $\tilde{u}$ be the worker's (reservation) utility of not working.
- To get the worker's participation, the contract must offer the worker a utility of at least $\tilde{u}$.
- The worker's utility cost of an effort level *e* is *c*(*e*).

# Incentives Contracting

**So the principal's problem is choose *e* to**

$$\max \Pi_p = f(e) - s(f(e))$$

**subject to** $s(f(e)) - c(e) \geq \tilde{u}.$ **(participation constraint)**

**To maximize his profit the principal designs the contract to provide the worker with her reservation utility level. That is, ...**

# Incentives Contracting

**the principal's problem is to**

$$\max \Pi_p = f(e) - s(f(e))$$

**subject to** $s(f(e)) - c(e) = \tilde{u}.$ **(participation constraint)**

# Incentives Contracting

**the principal's problem is to**

$$\max \Pi_p = f(e) - s(f(e))$$

**subject to** $s(f(e)) - c(e) = \tilde{u}.$ **(participation constraint)**

**Substitute for** $s(f(e))$ **and solve**

$$\max \Pi_p = f(e) - c(e) - \tilde{u}.$$

# Incentives Contracting

**the principal's problem is to**

$$\max \Pi_p = f(e) - s(f(e))$$

**subject to** $s(f(e)) - c(e) = \tilde{u}.$ **(participation constraint)**

**Substitute for** $s(f(e))$ **and solve**

$$\max \Pi_p = f(e) - c(e) - \tilde{u}.$$

**The principal's profit is maximized when**

$$f'(e) = c'(e).$$

# Incentives Contracting

$$f'(e) = c'(e) \Rightarrow e = e^*.$$

**The contract that maximizes the principal's profit insists upon the worker effort level *e** that equalizes the worker's marginal effort cost to the principal's marginal payoff from worker effort.**

# Incentives Contracting

$$f'(e) = c'(e) \Rightarrow e = e^*.$$

**The contract that maximizes the principal's profit insists upon the worker effort level *e** that equalizes the worker's marginal effort cost to the principal's marginal payoff from worker effort.**

**How can the principal induce the worker to choose e = e*?**

# Incentives Contracting

- $e = e^*$ must be most preferred by the worker.

# Incentives Contracting

- $e = e^*$ must be most preferred by the worker.
- So the contract $s(y)$ must satisfy the incentive-compatibility constraint;

$$s(f(e^*)) - c(e^*) \geq s(f(e)) - c(e), \text{ for all } e \geq 0.$$

# Rental Contracting

- Examples of incentives contracts:
  (i) Rental contracts: The principal keeps a lump-sum R for himself and the worker gets all profit above R; i.e.

$$s(f(e)) = f(e) - R.$$

- Why does this contract maximize the principal's profit?

# Rental Contracting

- Given the contract $s(f(e)) = f(e) - R$ the worker's payoff is

$$s(f(e)) - c(e) = f(e) - R - c(e)$$

and to maximize this the worker should choose the effort level for which

$$f'(e) = c'(e); \text{ that is, } e = e^*.$$

# Rental Contracting

- How large should be the principal's rental fee R?
- The principal should extract as much rent as possible without causing the worker not to participate, so R should satisfy
i.e.

$$s(f(e^*)) - c(e^*) - R = \tilde{u};$$

$$R = s(f(e^*)) - c(e^*) - \tilde{u}.$$

# Other Incentives Contracts

- (ii) Wages contracts: In a wages contract the payment to the worker is

$$\boldsymbol{s(e) = we + K.}$$

  *w* is the wage per unit of effort.
  *K* is a lump-sum payment.

- $\boldsymbol{w = f'(e^{*})}$ and *K* makes the worker just indifferent between participating and not participating.

# Other Incentives Contracts

- (iii) Take-it-or-leave-it: Choose $e = e^*$ and be paid a lump-sum $L$, or choose $e \neq e^*$ and be paid zero.
- The worker's utility from choosing $e \neq e^*$ is $-c(e)$, so the worker will choose $e = e^*$.
- $L$ is chosen to make the worker indifferent between participating and not participating.

# Incentives Contracts in General

- The common feature of all efficient incentive contracts is that they make the worker the full residual claimant on profits.
- I.e. the last part of profit earned must accrue entirely to the worker.